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Implementation of an integrated primary care cardiometabolic risk prevention and management network in Montréal: does greater coordination of care with primary care physicians have an impact on health outcomes?

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Abstract

Introduction: Chronic disease management requires substantial services integration. A cardiometabolic risk management program inspired by the Chronic Care Model was implemented in Montréal for patients with diabetes or hypertension. One of this study's objectives was to assess the impact of care coordination between the interdisciplinary teams and physicians on patient participation in the program, lifestyle improvements and disease control.

Methods: We obtained data on health outcomes from a register of clinical data, questionnaires completed by patients upon entry into the program and at the 12-month mark, and we drew information on the program's characteristics from the implementation analysis. We conducted multiple regression analyses, controlling for patient sociodemographic and health characteristics, to measure the association between interdisciplinary team coordination with primary care physicians and various health outcomes.

Results: A total of 1689 patients took part in the study (60.1% participation rate). Approximately 40% of patients withdrew from the program during the first year. At the 12-month follow-up (n = 992), we observed a significant increase in the proportion of patients achieving the various clinical targets. The perception by the interdisciplinary team of greater care coordination with primary care physicians was associated with increased participation in the program and the achievement of better clinical results.

Conclusion: Greater coordination of patient services between interdisciplinary teams and primary care physicians translates into benefits for patients.

Keywords: chronic diseases, Chronic Care Model, primary care services, medical practice, coordination of care

Highlights

- The primary care cardiometabolic risk management program implemented in Montréal improves health outcomes among patients with diabetes and hypertension.
- Greater coordination of care between interdisciplinary teams and primary care physicians translates into better outcomes for patients.
- Greater proximity between interdisciplinary teams and primary care physicians, as encouraged in the new primary care organization models, may represent a preferred avenue in the management of chronic diseases.

Introduction

Chronic disease management requires integration of the services intended for patients with these types of illnesses.[1,3] Among the care management models developed to improve case management, the Chronic Care Model (CCM) is the most widely used. It is based on integrating services at various levels of the health care system and is built around six interrelated elements involving different aspects of care organization.[3,5] One of those elements is the organization of services offer and delivery by setting up coordinated and integrated multidisciplinary teams in which clinical information sharing is systematic. A number of studies show that interventions based on the Chronic Care Model improve care processes and outcomes, particularly with respect to diabetes.[5-9]

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As part of the reform of health care services undertaken in Quebec in recent years, the Health and Social Services Centres (HSSCs) were given a mandate to improve the accessibility, continuity and coordination of services to the population, particularly by fostering interprofessional and interorganizational collaboration within local services networks, including primary care medical services.[10,11] In this regard, it should be noted that in Quebec, primary medical care services are not fully integrated on an organizational basis with other public health professional services. The implementation of CCM-based initiatives is a method of choice for consolidating network creation. The participation of primary care physicians, who are key players in managing chronic diseases,[3,12-15] in such integrated services networks produces benefits not only for patients, but also provides invaluable support for their medical practice.[16]

It was in this context that in 2011, Montréal's Health and Social Services Agency (the Health Agency), in conjunction with the HSSCs,* implemented a cardiometabolic risk-management program in primary care for patients with diabetes or hypertension (HT). The program was inspired by the CCM and was aimed at making lifestyle changes, controlling the disease, preventing complications and supporting self-management. In each HSSC, the program provides the following:

- An education centre that offers patients clinical interventions geared toward knowledge, motivation, self-management and lifestyle changes, complementing follow-up by primary care physicians. These interventions are carried out by an interdisciplinary team for patients referred by their family physician. For each patient, the program includes individual follow-up encounters with a nurse and a nutritionist over a period of two years, as well as group meetings with the interdisciplinary team (nurse, nutritionist, kinesiologist, pharmacist and social worker). The sequence of the program's clinical interventions is shown in Table 1. Detailed information on the content of the interventions is available from the authors upon request.
- Support for primary care physicians (e.g. continuing medical education activities, summary of guidelines, written information to be given to patients and program reference tools).
- The establishment and consolidation of links with specialists and among local network partners.
- Mechanisms to coordinate care, notably through implementation of a regional computerized chronic disease registry to facilitate flow of clinical information.

The objectives of the evaluation of the implementation of the program[17] were to assess the degree to which the program has been implemented in each participating HSSC and to identify the context-related factors that could explain the level of implementation; to evaluate the effects of the implementation of the different aspects of the program on patients' health indicators; to assess physicians' participation in the program and their appreciation of the program's effects on their patients and on their practices; and to assess the impact of implementing the program on strengthening local services networks. As part of the evaluation of the implementation of the program, the purpose of this article is to analyze the impact of care coordination between the HSSC interdisciplinary teams and primary care physicians on patient participation in the program

TABLE 1
Clinical interventions sequence in the cardiometabolic risk program, Montréal, Canada

		Visit 1	Visit 2 1 month	Visit 3 2 months	Visit 4 3 months	Visit 5 4 months	Visit 6 6 months	Visit 7 12 months	Visit 8 15 months	Visit 9 18 months	Visit 10 24 months
Individual clinical encounters	Nutritionist	x			x		x	x		x	x
	Nurse	x					If HT	x			x
Group meetings	Interdisciplinary team		x	x		x			x		
Evaluation of indicators	Lifestyle	x	x		x	x	x	x	x	x	x
	Blood pressure	x					If HT	x			x
	Blood tests (A1c, etc.)	x			x		x	x		x	x

Abbreviation: HT, hypertension.

* It should be noted that in 2014, the Health and Social Services Centres (HSSCs) were replaced by Integrated Health and Social Services Centres (IHSSCs) and the regional Health and Social Services Agencies were abolished. In Montréal, the 12 HSSCs were merged into five IHSSCs in April 2015. When this study was conducted, Montréal's Health and Social Services Agency was the organization responsible for planning and coordinating the program in Montréal, and the HSSCs were responsible for its local implementation.

and on lifestyle improvements and disease control.

Methods

Design

The evaluation of the implementation of the cardiometabolic risk program was based on a mixed design. We completed the implementation analysis using a qualitative research strategy (conducting semi-structured interviews with managers, gathering official documents, administering questionnaires to managers and interdisciplinary team members involved in each HSSC). Detailed results of the implementation analysis will be presented in another article. We used a quantitative approach similar to a quasi-experimental "pre and post" design to analyze the program's impact on patients. We drew the data from self-administered patient questionnaires that were completed onsite at the time of their entry into the program (T0) and at 12 months' follow-up (T12), and from the computerized chronic disease registry in which interdisciplinary team members entered clinical data after each patient encounter. Six of the 12 HSSCs in Montréal took part in the program evaluation. Their selection was based on volunteering and commitment to adhere to the general framework proposed by the Health Agency for the implementation of the program. Data were collected from March 2011 to August 2014.

Definition of variables and data sources

Dependent variables

The outcomes studied (dependent variables) regarded program participation and some patient health outcomes. Three variables described the participation of the patients in the program: withdrawals, extent of program exposure and extent of compliance with the program schedule. *Withdrawals* considered for the analysis were "confirmed withdrawals," i.e. patients who explicitly confirmed to the HSSC team their withdrawal from the program. The *extent of program exposure*, documented using data from the chronic disease registry, referred to the number of interventions (nutrition, nursing, group meetings) carried out since the patient's entry into the program, regardless of whether the sequence of interventions followed the planned timing. The *extent of compliance with the schedule* meant, for each patient, the percentage of nutrition, nursing and group interventions that took place within the follow-up time specified in the schedule since the patient's entry into the program. The follow-up times were defined for patients individually on the basis of their date of entry into the program, including an interval to account for the fact that visits did not necessarily take place at the exact time set out in the program schedule.

The patient health outcomes studied included disease control (achievement of glycated hemoglobin [A1c] and blood pressure [BP] targets) and lifestyle (level of physical activity and distribution of carbohydrate intake), as well as the impact of the disease on patient quality of life. We extracted data on disease control and lifestyle variables for each patient taking part in the study from the registry. The A1c values were measured using blood tests performed in a laboratory and entered into the registry by the nurse or the nutritionist. The *A1c target achieved* variable was dichotomized: less than or equal to 7% versus more than 7%. BP values were measured using an automatic sphygmomanometer and entered into the registry by the program nurse. The *BP target achieved* variable was dichotomized: lower than 140/90 (lower than 130/80 for patients with diabetes) versus 140/90 or higher (130/80 or higher for those with diabetes). Data regarding achievement of the physical activity target were documented at each patient visit by means of a brief questionnaire adapted from that used in the *Enquête québécoise sur l'activité physique et la santé*[18] study and entered into the registry by the nutritionist or the kinesiologist. This indicator measured, on a scale of 1 to 4, the number of days per week on which the patient did at least 30 minutes of physical activity, weighted by physical activity intensity. The *physical activity target achieved* variable was dichotomized (3 or 4 on the four-point scale versus less than 3). Measurement of the *distribution of carbohydrate intake* variable was based on an assessment of the patient's diet performed by the nutritionist at each visit, based on the objectives of daily distribution of carbohydrate intake explained in the *Coup d'œil sur l'alimentation de la personne diabétique*[19] document and expressed in two categories: balanced distribution, yes or no.

Questions regarding the measurement of the *impact of the disease on patient quality of life* were adapted from the *Audit of Diabetes Dependent Quality of Life* questionnaire.[20-22] They measured the patients' perceptions of what the various aspects of their life would look like if they did not have diabetes or hypertension, on a scale ranging from "considerably better" to "the same." The aspects measured included job or career opportunities, social life, sex life, opportunities for sports activities, vacations, travel or leisure activities, motivation to accomplish things, capacity to do physical activity and enjoyment of food. An index of the disease's impact on quality of life was calculated by averaging the responses to the various items, weighted by the importance (from "very important" to "not at all important") the patient gave to each life aspect, reported as a number out of 10.

Predictor variables

The two predictor variables in the study, which stemmed from information collected from HSSC program managers and interdisciplinary team members during the implementation analysis, focussed on the program's "external coordination." These variables reflected the coordination of care and interdisciplinary follow-up between the HSSC interdisciplinary teams and the family physicians providing patients' primary care for their diabetes or hypertension. The first variable, documented via questionnaire to HSSC program managers (and confirmed during the semi-structured interviews), was the *frequency of return of clinical information to physicians*. The HSSCs were divided into three categories: high frequency (written communication to the physicians after each individual or group encounter with the patients, and more often if needed), average (communication every six months and more often if needed) and low (once a year or less, or only if needed).

The second variable was HSSC teams' *perception of interdisciplinary follow-up and coordination of care with physicians*. As part of the implementation analysis, a brief questionnaire was administered to interdisciplinary team members (n varying from 5 to 10) in each HSSC that asked them to rate on a scale of 1 to 5, where 5 was "very high" and 1 was "very low," the extent of achievement with primary care physicians of the following elements: coordination of care, complementarity of care, interdisciplinary follow-up on patient progress and improvement, interdisciplinary follow-up on laboratory results and

interdisciplinary follow-up as needed should the patient become unstable. The HSSCs were divided into two categories with regard to the HSSC teams' perception of interdisciplinary follow-up and the coordination of care with physicians: high (≥ 60% of interdisciplinary team members answered 4 or 5 to at least 2 of the 5 questions) and low (< 60% answered 4 or 5 to at least 2 of the 5 questions).

Covariates

Among the control variables used in the analyses, individual characteristics were drawn from the questionnaire administered to the patients at their entry into the program: *age, sex, origin, language spoken at home, level of education, occupation, perception of health and number of comorbidities* (heart problems, stroke, asthma/chronic obstructive pulmonary disease, arthritis/osteoarthritis or mental health problems). *Primary care clinic type* referred to the primary health care organization where the patient receives care for diabetes or hypertension and was identified from patient program registration information. Clinic type could be a family medicine group (FMG); network clinic (NC); combined FMG-NC; local community health centre (LCHC); family medicine teaching unit; non-FMG non-NC group clinic; or solo clinic. The *body mass index* (BMI) measurement at T0 was drawn from the chronic disease registry. In the analysis models related to patient participation in the program (withdrawal, exposure to the program and compliance with the schedule), the *disease's impact on quality of life score* at T0 was also included as a covariate, as was the *disease knowledge score* at T0. The latter was calculated by averaging the answers to four questions adapted from the work of Battersby et al.[23] that rated, on a scale of 1 to 4 from "do not agree at all" to "strongly agree", the patient's knowledge of the disease (diabetes or HT), familiarity with the treatment, ability to detect signs and symptoms indicating a change in the progress of the illness and knowledge of what to do should such signs or symptoms occur.

Analysis method

We constructed multiple regression analysis models, controlling for sociodemographic and health characteristics of patients at T0, to measure the association between each of the study's dependent variables and 1) frequency of return of clinical information to primary care physicians; and 2) HSSC interdisciplinary team perception of interdisciplinary follow-up and care coordination with primary care physicians. Logistic, linear or Poisson-type regression models were used depending on the nature of the dependent variables.

We analyzed the data using Stata version 13 software (StataCorp LP, College Station, TX, USA). The project received the approval of Montréal's Health and Social Services Agency research ethics committee.

Results

In total, of the 2810 patients who enrolled in the program from March 2011 to August 2013, 1689 patients took part in the evaluation (participation rate of 60.1% upon entry into the program). Of those, approximately 40% withdrew from the program within the first year (n at T12 = 992). Withdrawals occurred mostly (41%) after the first visit and about 30% of patients who withdrew said that the program was too long and time consuming. The sociodemographic and health characteristics of patients with at least 12 months of follow-up are presented in Table 2. Among those patients, more than half (56.9%) were women, and the average age was 58.5 years. At T0, more than 60% of the participating patients had an A1c of 7% or less; more than 40% had a BP less than 140/90 (130/80 for patients with diabetes), but nearly two-thirds had a BMI of 30 or more and had at least one comorbidity.

At 12 months of follow-up, the patients' average extent of exposure to program interventions was approximately 75% of the total number of interventions planned by the program, while the schedule compliance rate was approximately 60%. Older patients, patients with a higher level of education and patients without comorbidities had better compliance with the schedule, and they had a lower rate of withdrawal within the first 12 months (data not shown).

The findings presented in Table 3 indicate that at 12 months, there was a significant increase in the proportion of patients who achieved the targets of balanced distribution of carbohydrate intake, A1c of 7% or less and BP less than 140/90 (< 130/80 for patients with diabetes). In addition, we noted a significant decrease in the disease's impact on quality of life (the average score went from 4.56 to 4.04 out of 10). However, despite a significant increase at three months and six months of follow-up (data not shown), the proportion of patients who achieved the physical activity target had not increased significantly at the 12-month mark.

With respect to patient participation in the program, the results of the multivariate regression analyses indicated that the frequency of communications sent to primary care physicians was associated with greater program exposure and closer compliance with the schedule at the 12-month mark (Table 4). More positive perception by the HSSC program team regarding interdisciplinary follow-up and coordination with primary care physicians was associated with a smaller proportion of program withdrawals and, among patients who withdrew, a smaller proportion of withdrawals before the three-month mark (Table 4). Health outcomes, with the exception of physical activity level, had a positive association with a better perception of the program team with respect to interdisciplinary follow-up and coordination with primary care physicians (Table 5).

Discussion

Like other studies that suggest that using CCM-based interventions improves glycemic control and blood pressure in patients with diabetes,[5-9] our findings show that the implementation of the cardiometabolic risk program in Montréal translated into positive health outcomes for patients, particularly in terms of lifestyle modification and achievement of A1c and BP targets.

The cardiometabolic risk program is CCM-based, especially in that it focusses on organizing services offer and delivery around coordinated and integrated multidisciplinary teams, as well as on sharing clinical information. Our findings show that greater coordination of care between the program's interdisciplinary team and primary care physicians, measured by the HSSC program team members' perception of interdisciplinary follow-up and coordination of care with physicians, is associated with better health outcomes for patients. It is interesting to note that this positive association occurs not only with regard to lifestyle modification and A1c and BP control, but also with regard to patients' perception of the impact of their disease on their quality of life. In addition, our results show that greater coordination

TABLE 2
Characteristics of patients with 12-month follow-up, upon entry into the cardiometabolic risk management program (n = 992), Montréal, Canada, 2011–2014

Sociodemographic characteristics of patients at T0		%[a]
Sex	Women	56.9
Age group	< 55 years	34.0
	55–64 years	34.3
	65 years or over	31.7
Origin	Born in Canada	72.5
Language spoken at home	French	81.4
Level of education (highest level completed)	Less than high school	12.9
	High school diploma	45.8
	College degree	13.7
	University degree	27.6
Occupation in the past six months	Retired or unemployed	56.9
Health characteristics of patients at T0		
Diagnosis	Diabetes/prediabetes without HT	8.0
	HT without diabetes/prediabetes	4.4
	Diabetes/prediabetes with HT	87.6
A1c (for patients with diabetes or prediabetes)	≤ 7%	62.7
	7%–8%	18.5
	> 8%	18.8
BP (all patients)	< 140/90 (or < 130/80 with diabetes)	41.0
BMI	< 25	8.1
	25 to < 30	28.1
	≥ 30	63.8
Waist measurement	Male ≤ 102 cm; female ≤ 88 cm	18.5
TC/HDL-C ratio	< 4.0	54.1
Perceived state of health	Very good/excellent	25.2
	Good	44.3
	Average/poor	30.5
Comorbidities	Heart disease	17.3
	Asthma/COPD	21.0
	Arthritis/osteoarthritis	37.8
	Mental health problem	22.3
Number of comorbidities	None	34.0
	1	37.4
	2 or more	28.6
Follow-up in primary care clinic		
Type of clinic where the patient receives follow-up for prediabetes/diabetes or HT	FMG, NC or FMG-NC	58.6
	LCHC or FMTU (non FMG or NC)	15.3
	Group or solo practice (including a small percentage of patients who didn't have a family physician at T0)	26.1

Abbreviations: A1c, glycated hemoglobin; BMI, body mass index; BP, blood pressure; COPD, chronic obstructive pulmonary disease; FMG, family medicine group; FMTU, family medicine teaching unit; HDL-C, high density lipoprotein cholesterol; HT, hypertension; LCHC, local community health centre; NC, network clinic; T0, entry of the patient into the program; TC, total cholesterol.

[a] Missing data are excluded from the frequency calculations.

TABLE 3
Changes in lifestyle, A1c, BP and perceived impact of the disease on quality of life from T0 to T12 in patients with 12-month follow-up, cardiometabolic risk management program, Montréal, 2011–2014

	% of patients achieving target values		N with measurement at T0 and T12	*p*-value[a]
	at T0	at T12		
Level of physical activity = 3 or 4 on four-point scale	36.7	38.7	703	.312
Balanced distribution of carbohydrate intake	22.2	35.9	708	< .001
A1c ≤ 7% (for those with pre/diabetes)	66.9	72.9	602	< .001
BP < 140/90 (with diabetes < 130/80)	41.8	47.1	612	.018
	Average score /10		N with measurement at T0 and at T12	*p*-value[a]
	at T0	at T12		
Impact of the disease on quality of life	4.56	4.04	481	< .001

Abbreviations: A1c, glycated hemoglobin; BP, blood pressure; T0, entry of the patient into the program; T12, 12-month follow-up.

[a] Tests for comparison of % and of mean scores between T0 and T12 for patients with measurements at both times.

of care with primary care physicians translates into improved program participation by registered patients and lower withdrawal rates (and fewer withdrawals before the three-month mark).

In a systematic literature review looking at the impact of each of the CCM's components on diabetes management in primary care in the United States, Stellefson et al. showed that none of the CCM components was solely responsible for the CCM's outcomes, and that it remained to be determined which combination of the components produced the best outcomes.[24] It would seem, however, that the implementation of several of the model's components is associated with better patient outcomes.[5,24,25] Our study does not make it possible to distinguish between the impacts of the program's various components on patient outcomes. However, it suggests that collaborative and coordinated care between interdisciplinary teams and primary care physicians is beneficial to patients. Although our data does not allow us to identify the mechanism responsible for this effect, we can assume that greater coordination of care translates into a better flow of patients' clinical information between the interdisciplinary teams and primary care physicians.

It is interesting to note that favourable perception by HSSC program team members regarding interdisciplinary follow-up and coordination of care with physicians appears to be more systematically associated with better patient outcomes than is

TABLE 4
Association between external coordination with primary care physicians and patient participation in the cardiometabolic risk management program, Montréal, 2011–2014

Predictor variables		Outcomes[a]							
		Confirmed withdrawals prior to T12[b]		Confirmed early withdrawals (before T3)[d]		Program exposure (number of interventions/10) at T12		Extent (%) of compliance with schedule at T12	
		n = 1015[c]		n = 388[c]		n = 741[c]		n = 741[c]	
		OR[e]	CI 95%	OR[e]	CI 95%	IRR[e]	CI 95%	β[e]	CI 95%
Frequency of communications sent to physicians (ref: low)	Average	1.33	0.86 to 2.05	0.86	0.43 to 1.71	1.20*	1.11 to 1.30	9.21*	5.90 to 12.52
	High	1.28	0.84 to 1.95	0.85	0.43 to 1.67	1.07**	0.99 to 1.15	0.95	−2.17 to 4.06
Interdisciplinary follow-up and coordination of care (ref: lesser)	Greater	0.35*	0.22 to 0.53	0.30*	0.12 to 0.77	1.01	0.95 to 1.08	−0.69	−3.36 to 1.99

Abbreviations: β, linear regression coefficient; CI, confidence interval; IRR, incidence rate ratio; OR, odds ratio; ref, reference category; T, time (in months) from entry into program.

[a] Each outcome studied was the subject of two separate multiple regression models, i.e. one for each predictor variable (frequency of communications sent to physicians, and interdisciplinary follow-up and coordination of care).

[b] Confirmed withdrawals prior to T12 = 1 (n = 513) and patients followed at T12 = 0 (n = 992).

[c] n effectively retained in the analyses, excluding missing data.

[d] Confirmed early withdrawals prior to T3 = 1 (n = 290) and confirmed withdrawals at or after T3 = 0 (n = 378).

[e] OR, IRR and β adjusted for patient sociodemographic and health characteristics (sex, age, origin, language spoken at home, level of education, occupation; number of comorbidities, perceived state of health and BMI at T0; achievement at T0 of targets for physical activity, distribution of carbohydrate intake, A1c and BP); score for knowledge of disease at T0; score for disease's impact on quality of life at T0; type of primary care clinic where the patient receives follow-up for prediabetes/diabetes or HT.

* $p < .05$.

** $p < .10$.

TABLE 5

Association between external coordination with primary care physicians and achievement of health outcomes at 12-month follow-up in the cardiometabolic risk management program, Montréal, 2011–2014

Predictor variables		Outcomes[a] at T12									
		Level of physical activity = 3 or 4 on four-point scale[b]		Balanced distribution of carbohydrate intake[d]		A1c ≤ 7%[e]		BP < 140/90 (with diabetes < 130/80)[f]		Score (/10) for impact of disease on quality of life	
		n = 650[c]		n = 651[c]		n = 554[c]		n = 564[c]		n = 404[c]	
		OR[g]	CI 95%	OR[g]	CI 95%	OR[g]	CI 95%	OR[g]	CI 95%	β[g]	CI 95%
Frequency of communications sent to physicians (ref: low)	Average	0.81	0.48 to 1.35	0.23*	0.14 to 0.39	0.54	0.26 to 1.09	1.58**	0.93 to 2.71	−0.03	−0.55 to 0.50
	High	0.72	0.43 to 1.20	0.30*	0.18 to 0.49	1.24	0.59 to 2.63	1.92*	1.13 to 3.27	−0.64*	−1.16 to −0.13
Interdisciplinary follow-up and coordination of care (ref: lesser)	Greater	1.07	0.70 to 1.63	1.51*	1.01 to 2.24	2.51*	1.31 to 4.82	1.49**	0.97 to 2.29	−0.55*	−1.01 to −0.09

Abbreviations: A1c, glycated hemoglobin; β, linear regression coefficient; BP, blood pressure; CI, confidence interval; OR, odds ratio; ref, reference category; T, time (in months) from entry into program.

[a] Each outcome studied was the subject of two separate multiple regression models, i.e. one for each predictor variable (frequency of communications sent to physicians, and interdisciplinary follow-up and coordination of care).

[b] Level of physical activity of 3 or 4 = 1 (n = 272) and level of physical activity of less than 3 = 0 (n = 431).

[c] n effectively retained in the analyses, excluding missing data.

[d] Balanced distribution of carbohydrate intake = 1 (n = 254) and unbalanced distribution of carbohydrate intake = 0 (n = 454).

[e] A1c ≤ 7% = 1 (n = 439) and A1c > 7% = 0 (n = 163).

[f] BP < 140/90 (with diabetes < 130/80) = 1 (n = 288) and BP ≥ 140/90 (with diabetes ≥ 130/80) = 0 (n = 324).

[g] OR and β adjusted for patient sociodemographic and health characteristics (sex, age, origin, language spoken at home, level of education, occupation; number of comorbidities, perceived state of health and BMI at T0; achievement at T0 of targets for physical activity, distribution of carbohydrate intake, A1c and BP), as well as the type of primary care clinic where the patient receives follow-up for prediabetes/diabetes or HT.

* $p < .05$.

** $p < .10$.

frequency of return of clinical information to physicians. This suggests that the simple implementation of formal communication mechanisms may not be sufficient in itself to foster better health outcomes in this type of program, and that the qualitative aspect of the interaction that develops between interdisciplinary teams and primary care physicians is of sizeable importance. In this regard, our results show no significant association between high frequency of return of clinical information to physicians and achievement of A1c of 7% or less; they also show a negative association with achievement of balanced distribution of carbohydrate intake. This last result may reflect a policy to increase the frequency of written communications with primary care physicians that may have been adopted by some HSSCs with a higher number of patients having greater difficulty achieving balanced distribution of carbohydrate intake.

Finally, our results show an association between the perceived importance of the interdisciplinary follow-up and the coordination of care with physicians by the program team and a lower patient withdrawal rate. This may be explained by a better coordinated and cohesive transmission of information to patients about the importance of adhering to the program by interdisciplinary team members and primary care physicians in settings where there is a greater coordination of care.

Strengths and limitations

One of this study's strengths is that it was conducted in a clinical context that reflects the reality of patients and stakeholders, in addition to having been carried out jointly with decision makers and stakeholders. The findings thus reflect the clinical reality, making them easier to generalize to similar contexts. Moreover, linking some organizational characteristics from the implementation analysis to patient outcomes is one of this study's major strengths. The various sources of data available for patient outcomes (questionnaires, clinical data) and the various health outcomes examined also made it possible to document the impact of coordination of care on a number of aspects related to patient follow-up within the program.

In this study, the presence of certain biases cannot be entirely eliminated. Data on lifestyle and perceived impact of the disease on quality of life could therefore include a social-desirability bias. As well, the overall clinical improvement measured in the participating patients may be due, at least in part, to the fact that less motivated patients dropped out of the program. However, it seems unlikely that the potential biases and the withdrawals would have a different impact on the results of the group of patients exposed to the program in the HSSCs where external coordination was greater, and the group exposed to less external coordination.

In addition, variables on lifestyle and A1c and BP control included a certain percentage of missing data at T0 (from 4% to 8%). We applied a hot-deck imputation procedure for missing data, meaning that each missing value was replaced with a randomly selected value from among the values observed in similar patients[26] with respect to age, sex and whether or not the target for the variable to be replaced was achieved in the next follow-up time for which these data were available.

This approach allowed us to reduce the impact of possible nonresponse bias.[37]

With respect to measuring "external coordination," it is important to bear in mind that the organizational characteristics of the program in the HSSCs stem from information collected during the implementation analysis. Their value is therefore the same for all patients registered in the program in a given HSSC. In addition, the relatively low number of participating clinical settings made it more difficult to observe variations and may have led to an underestimation of the strength of the measured associations. Otherwise, the measurement of interdisciplinary follow-up and coordination of care between HSSC program teams and physicians is based on the perception of interdisciplinary team members. The lack of information on the perception of primary care physicians regarding coordination of care with HSSC interdisciplinary teams is a gap.

Lastly, although the program evaluation participation rate was high, our data do not allow us to establish participants' representativeness without a doubt. Available data nonetheless indicate that patients taking part in the evaluation did not differ in any statistically significant manner from all program participants as regards age and sex.

Conclusion

The implementation of a cardiometabolic risk management and prevention program in Montréal exemplifies the integration of services between interdisciplinary teams and primary care physicians. Even in a context where primary medical care is not fully integrated with other public health professional services, such a program has the potential for successfully integrating services in chronic care management.

Our results show that greater coordination and integration of services to patients between interdisciplinary teams and primary care physicians, as set out in the CCM, translate into beneficial effects for patients with diabetes and hypertension. Particular attention should be paid to coordination and integration of services between interdisciplinary teams and primary care physicians when implementing chronic disease management programs. In that regard, greater proximity between the interdisciplinary teams and primary care physicians, as encouraged in the new primary care organizational models that include such teams, may represent a preferred avenue in the management of chronic diseases.

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Conflicts of interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Authors' contributions

Sylvie Provost, Raynald Pineault, Dominique Grimard, Pierre Tousignant, Johanne Desforges and Roxane Borgès Da Silva contributed to the concept and design of the study; data gathering, analysis and interpretation; and preparing the manuscript for submission. José Pérez, Michel Fournier and Yves Lévesque contributed to the data analysis. All the authors have been involved in drafting the manuscript; they also read and approved the final manuscript.

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Assessment of dysglycemia risk in the Kitikmeot region of Nunavut: using the CANRISK tool

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Abstract

Introduction: The Public Health Agency of Canada adapted a Finnish diabetes screening tool (FINDRISC) to create a tool (CANRISK) tailored to Canada's multi-ethnic population. CANRISK was developed using data collected in seven Canadian provinces. In an effort to extend the applicability of CANRISK to northern territorial populations, we completed a study with the mainly Inuit population in the Kitikmeot region of Nunavut.

Methods: We obtained CANRISK questionnaires, physical measures and blood samples from participants in five Nunavut communities in Kitikmeot. We used logistic regression to test model fit using the original CANRISK risk factors for dysglycemia (prediabetes and diabetes). Dysglycemia was assessed using fasting plasma glucose (FPG) alone and/or oral glucose tolerance test. We generated participants' CANRISK scores to test the functioning of this tool in the Inuit population.

Results: A total of 303 individuals participated in the study. Half were aged less than 45 years, two-thirds were female and 84% were Inuit. A total of 18% had prediabetes, and an additional 4% had undiagnosed diabetes. The odds of having dysglycemia rose exponentially with age, while the relationship with BMI was U-shaped. Compared with lab test results, using a cut-off point of 32 the CANRISK tool achieved a sensitivity of 61%, a specificity of 66%, a positive predictive value of 34% and an accuracy rate of 65%.

Conclusion: The CANRISK tool achieved a similar accuracy in detecting dysglycemia in this mainly Inuit population as it did in a multi-ethnic sample of Canadians. We found the CANRISK tool to be adaptable to the Kitikmeot region, and more generally to Nunavut.

Keywords: CANRISK, prediabetes, diabetes, dysglycemia, Nunavut, Inuit

Highlights

- The CANRISK questionnaire is a tool for assessing dysglycemia risk in Canada's multi-ethnic population.
- This study was conducted in a sample from Nunavut; 18% of study participants had prediabetes and 4% had undiagnosed diabetes.
- The CANRISK tool achieved similar accuracy in the mainly Inuit population as in a multi-ethnic sample of Canadians.
- The CANRISK tool was found to be adaptable to the Kitikmeot region, and more generally to Nunavut.

Introduction

Diabetes (types 1 and 2) and related complications place a heavy burden on Canadians and on the health care system.[1] Recent Canadian data show that 10% of adult Canadians aged 20 years and older have been diagnosed with diabetes.[2] Furthermore, it is estimated that at least one in five individuals with diabetes has not been diagnosed and is unaware that they have the disease.[3]

Risk factors for developing type 2 diabetes include adiposity, age, genetic predisposition, epigenetic factors, being male, unhealthy diet, physical inactivity and other comorbidities such as hypertension.[4,5] Surrogate genetic measures include family history of diabetes and ethnic origin, with individuals of South Asian[6] and First Nations[1] origin at particularly high risk for type 2 diabetes.

In 1987, a comprehensive review of medical charts of Canadian Inuit only identified 31 prevalent cases of diabetes in adults aged 25 years or over, resulting in an age-standardized prevalence of 0.6%.[7] The International Polar Year Inuit Health Survey for Adults 2007–2008 noted a diabetes prevalence of 5.1% based on the oral glucose tolerance test (OGTT), which was comparable to that of the general Canadian population.[8] However, the same survey observed high rates of obesity among the Inuit[8] compared to the general Canadian population.[9] The importance of obesity in the etiology of type 2 diabetes suggests that type 2 diabetes rates are likely to increase in the near future in this population.

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It is important to identify people at risk of developing type 2 diabetes and encourage them to make healthy lifestyle changes to prevent it, or at least postpone its onset, and to identify previously undiagnosed cases of type 2 diabetes so that treatment can begin.

The identification of an individual's diabetes or prediabetes status requires blood tests. If applied to entire populations (e.g. screening once every three years for Canadians aged 40 years and older as recommended by Canadian Diabetes Association 2013 guidelines[10]), the result is the screening of many low-risk people. One cost-effective option is to identify high-risk individuals through an initial questionnaire-based screen, and then to conduct further blood testing only on these individuals. Finland used this approach when it developed a questionnaire (FINDRISC)[11] based on known risk factors for type 2 diabetes. In Canada, the FINDRISC questionnaire was modified based on recommendations from an expert advisory committee to take into account Canada's multi-ethnic composition and other risk factors not captured by the FINDRISC that were considered relevant in the Canadian context.[12,13] The CANRISK questionnaire was piloted from 2007 to 2011 using a convenience sample of adults mainly aged 40 to 78 years living in seven provinces in conjunction with fasting plasma glucose (FPG) and oral glucose tolerance test (OGTT).[12,13] These data were used to build and test the CANRISK model using a calibration and validation sample. The predictive ability of the CANRISK model was compared to the FINDRISC model and a model including only body mass index (BMI), waist circumference, sex and age. The model was chosen to maximize the classification of true positives, and assess model fit and statistical significance of individual predictors with a calibration sample. The final model was then cross-validated on an independent sample.[12,14,15] Subsequent validations of the use of the CANRISK scoring tool among young adults (aged 20–39 years) in specific ethnic populations are currently underway. CANRISK is being used in a number of jurisdictions in Canada, such as New Brunswick[16] and the City of Toronto, and by organizations such as Shoppers Drug Mart[17] and the Canadian Diabetes Association.[18]

Other countries have developed type 2 diabetes risk assessment tools similar to FINDRISC and CANRISK, such as the Australian Type 2 diabetes risk assessment tool (AUSDRISK),[19] the UK Diabetes Risk Score Assessment tool[20] and the US type 2 diabetes risk test.[21] A key difference between these tools is the inclusion of different, country-specific ethnic groups (e.g. Aboriginal and Torres Strait Islander for AUSDRISK) during their developmental stages. Although the current version of CANRISK was developed based on a sample with many ethnicities including First Nations, it currently lacks validation for the Inuit population. The purpose of this study was to examine the fit of the CANRISK model in a mainly Inuit population, and to test the sensitivity and specificity of the current CANRISK tool and cut-off points in identifying dysglycemia (prediabetes and diabetes).

Methods

The Public Health Agency of Canada (PHAC) conducted a dysglycemia risk score study for the Nunavut population in conjunction with Nunavut Department of Health and Social Services and community public health authorities, following Tri-Council Policy Statement 2 guidelines.[22] Community engagement occurred through the Kitikmeot Inuit Association. Ethics approval was received from the Health Canada/Public Health Agency of Canada Research Ethics Board and licenced by the Nunavut Research Institute.

Study population and recruitment

During the period January 2013 to March 2013, we approached residents aged 30 years and over from the five communities in the Kitikmeot region of Nunavut including Cambridge Bay, Gjoa Haven, Kugaaruk, Kugluktuk and Taloyoak to participate in a dysglycemia risk assessment study. We excluded individuals with known diabetes status in order to match the methodology used in the original CANRISK study. Radio announcements, notices on social media such as Facebook and posters in the community were used to advertise the project. All people visiting the community health centres were asked to participate in the project and to spread the word to friends and family members. A $50 food voucher was given to participants who completed all the required information (questionnaire and blood tests).

Data collection

Individuals who provided informed consent were invited to the local public health unit to undergo a personal interview and anthropometric measurements and to give two blood samples. Study participants were weighed dressed in indoor clothing without shoes, using a digital standing scale. Height was determined using a standardized tape measure attached to the wall. Height and weight were measured to the nearest 1 cm and 100 grams, respectively. Waist circumference was measured as the minimum circumference between the umbilicus and xiphoid process, to the nearest half-centimetre. Community health workers within the communities were able to provide assistance to study participants in English, Inuinnaqtun and Inuktitut, as appropriate, and received standardized training on how to conduct the anthropometric measurements so that the measurements would be standardized across all five study communities.

The CANRISK questionnaire[16] included questions on sex, age, physical activity, fruit and vegetable consumption, history of high blood pressure, history of high blood glucose, family history of diabetes, ethnicity and education. The average length of time to complete the interview was less than five minutes. In Nunavut, due to interest from the local communities, these interviews were supplemented by dietary questions on the consumption of "junk food" (including sugar-sweetened beverages) and "country foods." "Junk food" encompassed potato chips, crisps, cheese puffs, sugary beverages such as soda, powdered sugar drinks (e.g. fruit drinks/sports drinks, iced tea, hot chocolate) and slush drinks. "Country foods" included muktuk, caribou, Musk ox, birds, animal liver or marine mammal meat such as ringed seal or whale, and fish such as arctic char or white fish.

Participants were requested to provide two blood samples: a fasting venous blood sample, and another venous blood sample two hours after drinking a 75 g glucose drink (constituting the OGTT), as recommended by the World Health Organization and the Canadian Diabetes Association 2013 guidelines.[10,23] Fasting and OGTT plasma glucose were measured on all blood samples by DynaLIFE$_{Dx}$ laboratory in Edmonton.

Data analysis

We calculated study participation rates by comparing the sample characteristics against

population data from the 2011 census, by individual community and the sample as a whole.

We analyzed age, BMI (kg/m^2) and waist circumference as categorical variables consistent with the categories on the CANRISK questionnaire.[13] The categories for age in years were 30 to 44, 45 to 54, 55 to 64 and 65 and older. The categories for BMI were less than 25, 25 to 29.9, 30 to 34.9 and 35 and higher.[24] Waist circumference categories were small (male < 94 cm and female < 80 cm), medium (male 94–102 cm and female 80–88 cm) and large (male > 102 cm and female > 88 cm).[25]

Family diabetes history was measured as a count of the number of categories of first-degree relatives with diabetes (ranging from 0 to 4). Education included some college or university, high school diploma and less than high school.

Other variables were binary, with yes or no responses to questions such as "Do you usually do some physical activity such as brisk walking for at least 30 minutes each day?"; "Have you ever been told that you have high blood pressure?"; "Have you ever been told that you have high blood sugar?"; and "Have you eaten country food in the past year?" We assessed fruit and vegetable consumption with the question "How often do you eat vegetables or fruits?" with response categories of "Every day" or "Not every day."

Dysglycemia was determined based on the results of participants' FPG and/or OGTT, with diabetes and prediabetes status defined according to WHO standards.[23] Individuals were classified as having prediabetes if they had an FPG level of 6.1 to less than 7.0 mmol/L, and/or an OGTT of 7.8 to 11.0 mmol/L. Individuals were classified as having diabetes if they had an FPG level of 7.0 mmol/L or higher, and/or a 2-hour plasma glucose post-ingestion of 75 g of glucose of 11.1 mmol/L or higher.

First, we conducted binary logistic regression, with the CANRISK variables plus the supplementary diet variables, with presence or absence of dysglycemia as the outcome variable. We conducted a second binary logistic regression, forcing only the CANRISK variables in the model. We used the Hosmer–Lemeshow goodness of fit test to assess model fit, and the pseudo-R-square statistic to compare these models. We calculated odds ratios (ORs) and 95% confidence intervals (CIs). We used the area under the receiver operating curve (AUC ROC) to assess the predictive ability of the models. Scores range from 0.5 (no predictive ability) to 1.0 (perfect predictive ability). All analyses were conducted in SAS 9.3 (SAS Institute Inc., Cary, NC, USA).

Second, we ascribed CANRISK scores to participants based on the publicly available CANRISK tool and classified scores as positive or negative with reference to a series of cut-off points: slightly elevated (≥ 21), moderate (≥ 29), balanced (≥ 32) and high risk (≥ 33).[13] A score equal to or above the cut-off point was coded as positive and a score below the cut-off point was coded as negative. Sensitivity is the proportion of those who have a positive CANRISK score among those with a positive FPG and/or OGTT. Specificity is the proportion of those with a negative CANRISK score among those with a negative FPG and negative OGTT. The positive predictive value is the probability that subjects with a positive CANRISK risk score had a positive FPG and/or OGTT. The accuracy rate is the number of positive CANRISK scores confirmed by positive FPG and/or OGTT tests and the number of negative CANRISK scores confirmed by negative FPG and negative OGTT tests out of the total number of participants. We calculated these statistics in this study to determine if the current CANRISK tool and cut-off points could be extended to this Inuit population.

Results

A total of 303 CANRISK surveys and valid OGTT records were collected from the five selected communities, which covered approximately 11.6% (303/2614) of the local population aged 30 years or older (Table 1). Approximately half of the participants were aged 30 to 45 years, two-thirds were female and 84% were Inuit.

Table 2 shows the primary risk characteristics of study participants. Of the surveyed population, 67% were overweight or obese, and 56% had a high-risk waist circumference of more than 88 cm for females and more than 102 cm for males. The mean CANRISK score for this sample (N = 303) was 29.0, (SD = 12, median = 28, minimum = 0 and maximum = 65).

From laboratory testing, a total of 18% of the participants in the study were identified as having prediabetes, and 4% were identified as having diabetes. The proportion of the sample identified as having prediabetes ranged from 12% to 22% depending on the community (Table 3).

Table 4 provides the results of the logistic regression analyses. Age and macrosomia

TABLE 1
CANRISK Kitikmeot Region (Nunavut) study participation rates by community, Canada, 2013

Community	Community population[a] aged 30 and over		Participants (n) and community coverage (%)		
	Males	Females	Males	Females	Total
Cambridge Bay	406	365	33 (8.1%)	48 (13.2%)	81 (10.5%)
Gjoa Haven	276	233	24 (8.7%)	50 (21.5%)	74 (14.5%)
Kugaaruk	171	149	11 (6.4%)	18 (12.1%)	29 (9.1%)
Kugluktuk	358	295	22 (6.1%)	54 (18.3%)	76 (11.6%)
Taloyoak	172	179	14 (8.1%)	29 (16.2%)	43 (12.3%)
Total[b]	1393	1221	104 (7.5%)	199 (16.3%)	303 (11.6%)

[a] Population estimates are based on the 2011 census counts adjusted for net census undercoverage.

[b] Kitikmeot region totals include unorganized areas and outpost camps.

TABLE 2
Risk characteristics of CANRISK Kitikmeot Region (Nunavut) study participants, Canada, 2013

	Males % (n)	Females % (n)	Total % (n)	*p*
Age				
< 45	50.0 (52)	47.2 (94)	48.2 (146)	.15
45–54	26.0 (27)	21.6 (43)	23.1 (70)	
55–64	9.6 (10)	19.6 (39)	16.2 (49)	
65+	14.4 (15)	11.6 (23)	12.5 (38)	
BMI				
< 25	39.4 (41)	29.6 (59)	33.0 (100)	.05
25 to < 30	26.9 (28)	24.1 (48)	25.1 (76)	
30 to < 35	21.2 (22)	20.6 (41)	20.8 (63)	
35+	12.5 (13)	25.6 (51)	21.1 (64)	
Waist circumference[a]				
Small	38.8 (40)	15.0 (29)	23.3 (69)	< .001
Medium	26.2 (27)	17.1 (33)	20.3 (60)	
Large	35.0 (36)	67.9 (131)	56.4 (167)	
Education				
Some college or university	24.0 (25)	23.1 (46)	23.4 (71)	.52
High school	10.6 (11)	6.0 (12)	7.6 (23)	
Less than high school	65.4 (68)	70.9 (141)	69.0 (209)	
30 Minutes daily physical activity				
Yes	79.8 (83)	82.4 (164)	81.5 (247)	.58
No	20.2 (21)	17.6 (35)	18.5 (56)	
Eat fruits and vegetables daily				
Yes	39.4 (41)	36.4 (72)	37.4 (113)	.60
No	60.6 (63)	63.6 (126)	62.6 (189)	
History of high blood presure				
No	69.2 (72)	65.3 (130)	66.7 (202)	.49
Yes	30.8 (32)	34.7 (69)	33.3 (101)	
Previous high blood sugar				
No	—	—	87.1 (263)	< .001
Yes	—	—	12.9 (39)	
Macrosomia (females only)				
No	n/a	76.4 (152)	n/a	n/a
Yes	n/a	23.6 (47)	n/a	
Country food				
Yes	56.7 (59)	52.8 (105)	54.1 (164)	.06
No	43.3 (45)	47.2 (94)	45.9 (139)	
Daily junk food				
Yes	14.4 (15)	7.5 (15)	9.9 (30)	.51
No	85.6 (89)	92.5 (184)	90.1 (273)	
Total	34.3 (104)	65.7 (199)	100 (303)	

Abbreviation: n/a, not applicable.

Note: "—" signifies n < 5, suppressed to protect privacy.

[a] Waist circumference: small, males < 94 cm and females < 80 cm; medium, males 94–102 cm and females 80–88 cm; large, males > 102 cm and females > 88 cm.

TABLE 3
Dysglycemia status of CANRISK Kitikmeot Region (Nunavut) study participants, Canada, 2013

Community	Prediabetes % (n)	Diabetes[a] % (n)	Dysglycemia % (n)
Cambridge Bay	22 (18)	9 (7)	31 (25)
Gjoa Haven	12 (9)	0	12 (9)
Kugaaruk	21 (6)	0	21 (6)
Kugluktuk	—	—	21 (16)
Taloyoak	—	—	26 (11)
Total	18 (55)	4 (12)	22 (67)

Note: "—" signifies n < 5, suppressed to protect privacy.

[a] Since participants with confirmed diabetes were excluded from the CANRISK survey, only previously undiagnosed diabetes cases were included in this column.

(giving birth to a baby weighing 4.1 kg [9 lbs] or more) were significant predictors of dysglycemia in the fully adjusted models. The odds of dysglycemia increased with age although not all estimates were statistically significant; the odds of dysglycemia by BMI and waist circumstance appeared to follow a U-shape. In Model 1, which included supplementary diet variables, the Hosmer–Lemeshow goodness of fit for the full model was $p = .35$, the max-rescaled pseudo-R-square was 0.23, and area under the curve (AUC) was 0.75. For Model 2, the CANRISK model without supplementary variables, the Hosmer–Lemeshow goodness of fit was $p = .94$, the max-rescaled pseudo-R-square was 0.22 and AUC was 0.75. The max-rescaled pseudo-R-square was marginally better for Model 1, which is to be expected given it is a model with more predictors. The Hosmer–Lemeshow goodness of fit indicated that both models fit the data well. Both models have comparable accuracy based on the AUC.

We calculated the CANRISK score for each individual. Sensitivity and specificity calculations based on the CANRISK thresholds[12] are presented in Table 5. When we used the "high" CANRISK score of 33 or over as the classification criterion for dysglycemia, the sensitivity was 61% and the specificity was 67%; however, when we used the "slightly elevated" CANRISK score of 21 or over, the sensitivity was 85% and the specificity was 31% (Table 5). A post-hoc power calculation indicated that the study was powered at 0.84 against a null hypothesis of the dysglycemia prevalence rate of 0.15 ($\alpha = 0.05$).

Discussion

The prediabetes (18% vs. 16%) and the undiagnosed diabetics (4% vs. 5%) estimates in the Kitikmeot region of Nunavut were very similar to those identified in the data collection sites in seven provinces (British Columbia, Saskatchewan, Manitoba, Ontario, New Brunswick, Nova Scotia and Prince Edward Island) in the original CANRISK study.[12] The Nunavut population sampled was significantly younger on average than that obtained in other CANRISK data collection sites, which should have resulted in fewer identified cases. However, the prevalence of undiagnosed diabetes in this convenience sample also approximates the prevalence of diabetes identified in the International Polar Year Inuit Health Survey for Adults based on OGTT.[8]

The prevalence of dysglycemia increased exponentially with age in the current study population, with the odds doubling with every 10 years of age, whereas a more modest linear increasing trend in the OR for age[12] was noted for original CANRISK data. It is unclear whether this is a function of a relatively small sample size, or whether it reflects some underlying difference in risk by age for what was largely an Inuit population.

The association between BMI and dysglycemia in Nunavut did not show a linear increase, as was reported for the original CANRISK study;[12] instead, a U-shaped relationship is suggested, though it is not statistically significant. A similar U-shaped relationship is also suggested for waist circumference, though the relationship here is also not statistically significant. These observations suggest that BMI cut-off points representing categories of increased health risk may need to be adjusted for Inuit populations. This finding is supported by a study of Inuit in Greenland, which observed the tendency for shorter legs relative to torso among the Inuit would result in a BMI overweight cut-off point of 27 instead of the WHO standard of 25.[26] Similarly, a BMI of around 27 among Inuit corresponded to the same degree of dyslipidemia as observed for a BMI of 25 among non-Inuit.[26]

In the last few decades, traditional foods have been replaced in Indigenous communities in Canada by processed foods, which are higher in refined carbohydrates, fat, sodium and sugar.[27,28] This change has had an impact on the development of diabetes and other chronic diseases.[27,28] Although not statistically significant, the results of our study suggested that frequent consumption of country food was associated with lower odds of dysglycemia, and that junk food was positively associated with dysglycemia.

The Inuit population of Nunavut is the youngest in Canada, with a median age of 23 years, compared to that of the non-Indigenous population in Canada (41 years).[29] Although the CANRISK tool has been previously validated for a multi-ethnic sample, our purpose in this study was to target the Inuit population. This meant that our sample was younger than that of the previous CANRISK study. However, two-thirds of our participants were still in the group aged 40 years and over.

Our study was consistent with the previous CANRISK study when we used the "balanced" and "high" scoring categories to indicate individuals' risk of dysglycemia.[12] Comparing the "high" category (≥ 33 points) to the data from the seven-province CANRISK, we found a sensitivity of 61% versus 66%; specificity of 67% versus 70%; positive predictive value of 34% versus 36% and a total accuracy rate of 65% versus 64%. It is important to note that there is no ideal or recommended sensitivity and specificity for a tool to identify individuals with a high risk of dysglycemia. Although it is desirable to have a screening tool that is both highly sensitive and highly specific, this is

TABLE 4
Logistic regression models using CANRISK, Kitikmeot Region (Nunavut), Canada, 2013

	Model 1. CANRISK model with supplementary diet variables N=303		Model 2. CANRISK model N = 303	
Risk factor	**Adjusted OR**	**95% CI**	**Adjusted OR**	**95% CI**
Age (years)				
< 44	Ref		Ref	
45–54	1.46	0.63–3.35	1.44	0.63–3.30
55–64	4.12[a]	1.73–9.82	3.79[a]	1.62–8.90
65+	7.43[a]	2.93–18.81	6.98[a]	2.79–17.48
BMI group				
< 25	Ref		Ref	
25 to < 30	0.68	0.17–2.64	0.72	0.19–2.80
30 to < 35	0.68	0.15–3.05	0.71	0.16–3.16
35+	1.33	0.30–5.81	1.44	0.33–6.27
Waist circumference[b]				
Small	Ref		Ref	
Medium	0.37	0.10–1.45	0.36	0.09–1.43
Large	1.24	0.27–5.74	1.17	0.26–5.40
Education				
Some college or university	Ref		Ref	
High school	1.09	0.29–4.01	1.00	0.27–3.70
Less than high school	0.70	0.30–1.62	0.70	0.31–1.59
30 minutes daily physical activity				
Yes	Ref		Ref	
No	1.33	0.62–2.85	1.35	0.63–2.91
Eat fruits and vegetables daily				
Yes	Ref		Ref	
No	0.97	0.47–1.99	1.02	0.50–2.07
History of high blood pressure				
No	Ref		Ref	
Yes	0.89	0.45–1.75	0.90	0.46–1.75
Family history of diabetes				
No	Ref		Ref	
First degree relative (count)	0.87	0.41–1.85	0.85	0.40–1.79
Sex				
Female	Ref		Ref	
Male	1.45	0.69–3.06	1.45	0.69–3.07
Previous high blood sugar				
No	Ref		Ref	
Yes	1.47	0.59–3.70	1.35	0.55–3.32
Macrosomia (females only)[c]				
No	Ref		Ref	
Yes	2.65[a]	1.12–6.25	2.63[a]	1.13–6.09
Eat country food weekly				
No	Ref			
Yes	0.73	0.40–1.37		
Eat/drink junk food daily				
No	Ref			
Yes	1.53	0.53–4.47		
Model fit statistics and ROC				
Hosmer–Lemeshow goodness of fit (*p*)	0.35		0.94	
Max-rescaled pseudo-R-square	0.23		0.22	
AUC	0.75		0.75	

Abbreviations: AUC, area under the curve; CI, confidence interval; OR, odds ratio; Ref, reference group; ROC, receiver operating curve.

Note: Shaded cells signify variables not included in the model.

[a] Indicates significance at $p < .05$.

[b] Waist circumference: small, males < 94 cm and females < 80 cm; medium, males 94–102 cm and females 80–88 cm; large, males > 102 cm and females > 88 cm.

[c] The macrosomia estimate was calculated in the same model as the other parameters. Males were included as a third category, separate from the reference group.

TABLE 5
Validation of CANRISK tool and score thresholds in Kitikmeot Region (Nunavut), Canada, 2013

Validation analysis	CANRISK score			
	Slightly elevated ≥ 21	Moderate ≥ 29	Balanced[a] ≥ 32	High ≥ 33
Sensitivity	85.1%	65.7%	61.2%	61.2%
Specificity	31.4%	55.5%	65.7%	66.5%
Positive predictive value	26.0%	29.5%	33.6%	34.2%
Total accuracy rate	43.2%	57.8%	64.7%	65.3%

[a] A balanced score of CANRISK is an optimal score that attempts to balance the sensitivity and specificity of the test.

usually not possible, as increasing one reduces the other. The chosen balance is a compromise that weights the relative importance of minimizing false positives and false negatives. What we have done here is to report and compare our sensitivity and specificity rates to what exists in the literature for different screening tools, or for the same tool in a different population. Comparing our rates of sensitivity and specificity to those of existing biochemical tests[30] can help to determine how useful CANRISK could be as a risk-screening tool. In general, questionnaire screening tools have lower sensitivity and specificity than biochemical tests but are usually useful for educating in particular people at high risk of developing type 2 diabetes, or in situations where the advantages of ease and cost associated with questionnaires compared to biochemical tests outweigh the loss of sensitivity and specificity.

The OGTT provides a sensitivity of 90% to 93%, with a specificity of 100% for identifying individuals with diabetes, and is therefore the gold standard test.[31] The FPG test (7.0 mmol/L or higher) yields a sensitivity of 40% to 59% with a specificity of 96% to 99%.[31] The FINDRISC, widely used in European populations, which was used as a model in the development of the CANRISK, is the most-researched diabetes screening tool.[32] A FINDRISC score of greater than or equal to 12 yields a sensitivity of 78% and a specificity of 62%; a cut-off point of FINDRISC greater than or equal to 10 results in a sensitivity of 84% and a specificity of 61%. The original CANRISK tool had a sensitivity of 70%, and a specificity of 67% using a cut-off point of 32, in a larger, multi-ethnic sample of Canadians.[12] It has been used primarily as an educational tool and its potential role in clinical screening has not been assessed. Given all of this information, one can see that the predictive ability of the CANRISK tool in the Nunavut population is acceptable compared to what else is available (apart from the OGTT), with the additional advantage that it is a simple, easy-to-use, self-administered questionnaire.

Like the previous analysis of CANRISK that was based on provincial populations, we opted to use FPG and/or OGTT as the basis for determining dysglycemic status. The choice of which test to use is problematic in that the tests are by no means entirely interchangeable, and groups identified by each test do not always overlap. For example, the analysis of the CANRISK data for the seven provinces noted that FPG would have failed to detect 52% of the diabetes cases and 59% of the prediabetes cases identified by the 2-hour oral glucose challenge test.[12] However, we used both the FPG and OGTT, and given the high sensitivity of OGTT, it is unlikely that we have failed to detect true cases. The choice to use FPG and/or OGTT in the current analysis was in part to provide comparability to the data generated by the earlier seven-province CANRISK analysis.[12,13] Also, OGTT is still considered by most clinicians to be the gold standard for the diagnosis of diabetes.

Strengths and limitations

Given lifestyle changes in the last few decades, more evidence is needed regarding diabetes prevention and early detection among Inuit populations. Our study provides emerging evidence in a timely manner as to how the CANRISK tool may be applied to the Inuit population.

Our study had several limitations. Females were overrepresented in our sample, although the age distribution was comparable to that of the corresponding 2011 census.[33] The effect of the oversampling of females is important only if there are significant interactions between the risk factors in the model and dysglycemia. The proportions of people in our sample who had less than a high school education (69%) or who were Inuit (84%) were also comparable to census data (62% and 90%[33]), suggesting that although we used a convenience sample, with the exception of oversampling females, our study appeared to have been broadly representative of the study population.

This study relied on a convenience sample of volunteers, and it was not possible to fully investigate the difference between volunteers and the remainder of the population. Therefore, the rates of undiagnosed diabetes and prediabetes among volunteers may not be representative of the region studied or the wider population of Nunavut. Additionally, because we excluded participants with diagnosed diabetes, we are only able to present rates of prediabetes and undiagnosed diabetes. The total burden of dysglycemia in these communities cannot be estimated, due to low participation rates and our inability to determine systematically whether participants differed from nonparticipants. Perhaps the biggest limitation of the study was its small sample size and the resulting lack of precision in our odds ratios.

As with other diabetes screening tools such as AUSDRISK[19] and FINDRISC,[18] CANRISK used a single predictive model for all included ages. Although CANRISK performed reasonably well at predicting dysglycemia within our population, given our small sample size, we were not able to examine reliably how well CANRISK performed for those aged under 40 years. Although the CANRISK tool was developed from a sample that included individuals aged 18 years and older, the CANRISK tool is currently recommended for those

aged 40 years and older. This limitation is particularly significant for Inuit populations, given their much younger age distribution. Further research is needed to address how well diabetes-risk screening tools perform for younger populations.

Conclusion

A logistic regression model had acceptable model fit when we used CANRISK variables to predict dysglycemia. Further, categories of risk based on scores from the original CANRISK tool achieved a similar accuracy in detecting true dysglycemia in this mainly Inuit sample as in a multi-ethnic sample in Canada. We found the CANRISK tool to be adaptable to the Kitikmeot region of Nunavut, and therefore the tool may be utilized in a similar way in Nunavut region as well. Using the CANRISK tool to identify the levels of dysglycemia risk, individuals, communities and local health authorities can take appropriate measures to reduce the burden of dysglycemia in the Inuit population.

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Conflicts of interest

The authors have no conflicts of interest to disclose.

Authors' contributions

YJ, YM and HM contributed substantially to the study design and drafted the paper. YM, SRVK and YJ analysed the data. MS and RC developed tools and completed data acquisition. HO, GA, MG, HM, YM, SRVK and YJ reviewed and revised the paper. All authors read and gave final approval of this version to be published and agreed to be guarantors of the work.

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Measuring positive mental health in Canada: construct validation of the Mental Health Continuum—Short Form

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Abstract

Introduction: Positive mental health is increasingly recognized as an important focus for public health policies and programs. In Canada, the Mental Health Continuum—Short Form (MHC-SF) was identified as a promising measure to include on population surveys to measure positive mental health. It proposes to measure a three-factor model of positive mental health including emotional, social and psychological well-being. The purpose of this study was to examine whether the MHC-SF is an adequate measure of positive mental health for Canadian adults.

Methods: We conducted confirmatory factor analysis (CFA) using data from the 2012 Canadian Community Health Survey (CCHS)—Mental Health Component (CCHS-MH), and cross-validated the model using data from the CCHS 2011–2012 annual cycle. We examined criterion-related validity through correlations of MHC-SF subscale scores with positively and negatively associated concepts (e.g. life satisfaction and psychological distress, respectively).

Results: We confirmed the validity of the three-factor model of emotional, social and psychological well-being through CFA on two independent samples, once four correlated errors between items on the social well-being scale were added. We observed significant correlations in the anticipated direction between emotional, psychological and social well-being scores and related concepts. Cronbach's alpha for both emotional and psychological well-being subscales was 0.82; for social well-being it was 0.77.

Conclusion: Our study suggests that the MHC-SF measures a three-factor model of positive mental health in the Canadian population. However, caution is warranted when using the social well-being scale, which did not function as well as the other factors, as evidenced by the need to add several correlated error terms to obtain adequate model fit, a higher level of missing data on these questions and weaker correlations with related constructs. Social well-being is important in a comprehensive measure of positive mental health, and further research is recommended.

Keywords: mental health, positive mental health, surveys and questionnaires, factor analysis

Highlights

- Positive mental health can be measured through a three-factor model, consisting of emotional well-being, psychological well-being and social well-being.
- While a three-factor model was supported, the social well-being factor did not perform as well as the other two factors.
- Further research is required to develop a more valid and reliable measure of social well-being for the Canadian context.

Introduction

It is increasingly acknowledged that a state of health is not the "absence of disease," and that both physical and mental health are required for comprehensive well-being. Within this context, the role of mental health is gaining attention because it is associated with better functioning, physical health and ability to contribute to society.[1] The Public Health Agency of Canada (PHAC) defines mental health as "the capacity of each and all of us to feel, think, and act in ways that enhance our ability to enjoy life and deal with the challenges we face. It is a positive sense of emotional and spiritual well-being that respects the importance of culture, equity, social justice, interconnections and personal dignity."[2,p.3] This is similar to the World Health Organization definition which states, "Mental health is a state of well-being in which an individual realizes his or her own abilities, can cope with the normal stresses of life, can work productively and is able to make a contribution to his or her community."[3]

A number of measures of positive mental health have been developed. These include the Warwick-Edinburgh Mental Well-Being Scale (WEMWBS),[4] Diener's Flourishing Scale,[5] Huppert and So's scale,[6] the PERMA profiler based on Seligman's model of positive psychology[7] and Keyes' Mental Health Continuum (MHC).[8,9] Most have been developed in the context of understanding individual differences in well-being, with the exception of the WEMWBS, which was developed specifically to monitor population well-being.

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The MHC is a measure of positive mental health developed by Keyes[8] based on a three-factor model of well-being including emotional, psychological and social well-being. The emotional well-being component assesses positive affect, life satisfaction and interest in life, and is informed by the work of Bradburn[10] on positive affect and Cantril[11] on life satisfaction. The psychological well-being component assesses functioning in six domains—autonomy, mastery, personal growth, positive relations with others, purpose in life and self-acceptance—as developed by Ryff.[12] Finally, the social well-being component is based on the work of Keyes. It reflects individuals' appraisals of their experiences in society and includes the five concepts of social contribution, social acceptance, social coherence, social actualization and social integration.[13]

The original Mental Health Continuum tool included subscales for emotional, psychological and social well-being, and consisted of 40 items. Keyes used a distribution-based criterion to identify a high level of positive mental health, called "flourishing" and defined as scoring in the top tertile of at least one of the emotional well-being scales, and at least six of the 11 social and psychological well-being scales. Using this approach, 17.2% of the sample was considered to be "flourishing," 56.6% was moderately mentally healthy, and 12.1% was "languishing."[8] Because the initial MHC tool was lengthy, Keyes subsequently chose "the most prototypical items representing the construct definition for each facet of well-being"[9,p.1] to create the 14-item Mental Health Continuum—Short Form (MHC-SF), which is widely used today and the focus of this study. It is unclear whether any analysis aside from investigator judgment was used to inform the choice of items for the short form of the scale. The MHC-SF was implemented in both the 2011–2012 Annual and 2012 Mental Health cycles of the Canadian Community Health Survey (CCHS).

While the MHC-SF can be used as a continuous scale score, most frequently it is used to report on the prevalence of "flourishing," which is defined as a respondent responding "almost every day" or "every day" to at least one of the three emotional well-being questions, and six of 11 psychological and social well-being questions (at least one plus at least six). Keyes proposes that this approach to identifying "flourishing" is "similar to the standard used to assess and diagnose major depressive episode."[8,9] We would argue that it is not necessarily appropriate to apply an approach to diagnosing a mental illness to the identification of positive states of mental health. Furthermore, this approach to identifying "flourishing" can result in an individual with only high scores on psychological well-being (six items), and only low scores on social well-being (five items), being described as flourishing, which is inconsistent with the theory that positive mental health requires high levels of emotional, psychological and social well-being.

A number of studies have confirmed the three-factor model and adequate scale functioning of the MHC-SF. Keyes et al.[14] conducted a confirmatory factor analysis (CFA) on scale responses in a sample of Setswana-speaking South Africans and confirmed the three-factor model. Lamers et al.[15] reported that analyses supported the three-factor model, but also found that the social well-being subscale had only moderate reliability, while the psychological and emotional well-being subscales had high reliability. A three-factor structure was also confirmed in a study with Dutch, South African and Iranian respondents.[16] However, in order to obtain adequate model fit, some item residuals were allowed to covary.

Studies that have measured flourishing using this approach (at least one plus at least six) have produced a range of prevalences of flourishing: 49.3% among American college students,[17] 37.9% among American youth,[18] 20% in a Setswana-speaking sample of South Africans,[14] and 28.5% among Italian adults.[19] Using this approach to scoring the MHC-SF, the prevalence of flourishing among Canadians was 76.9% in 2012.[20] The markedly higher prevalence of flourishing in Canada compared to other countries has raised concern about the functioning of this scale on population surveys in the Canadian context.

The purpose of this paper is to describe the measurement properties of the MHC-SF in the Canadian context, to examine its factor structure, and to propose a conceptually and empirically consistent approach to reporting on positive mental health based on this set of questions. Criterion-related validity and internal consistency are also examined. Positive correlations with the MHC-SF subscales were expected with self-rated mental health, life satisfaction and sense of belonging to the community. Negative correlations were expected with the WHO Disability Assessment Schedule (WHODAS), negative social interactions and psychological distress. Cronbach's alpha coefficients were expected to demonstrate good internal consistency without redundancy of items, with scores in the mid 0.80 range.[21]

Methods

Data

The 2012 Canadian Community Health Survey—Mental Health Component (CCHS-MH) is a household sample of 25 113 Canadians aged 15 years and over in the 10 provinces excluding individuals living on reserves and other Aboriginal settlements, Canadian Forces personnel and residents of institutions.[22] Less than 3% of the Canadian population was excluded. A multistage sampling design based on the Labour Force Survey was used to ensure adequate coverage by age group and sex, in each province. Response was voluntary. The combined (household and person) response rate was 68.9%. The data collection period was from 2012 January 02 to 2012 December 31. Data were collected using computer assisted personal interviewing (CAPI) and telephone interviewing (CATI); 87% of interviews were conducted in person. Proxy interviews were not permitted for this survey. Statistics Canada calculated sample weights to ensure that weighted estimates represented the Canadian household population in the 10 provinces.

The Canadian Community Health Survey—Annual Component (CCHS) is an ongoing household sample of approximately 65 000 Canadians aged 12 years and over in the 10 provinces and three territories, excluding individuals living on reserves and other Aboriginal settlements; full-time Canadian Forces personnel; persons living in the Quebec health regions of Région du Nunavik and Région des Terres-Cries-de-la-Baie-James; and residents of institutions.[23] Less than 3% of the Canadian population is excluded. The CCHS uses three sampling frames to select the sample of households: an area frame based on the Labour Force Survey (40.5%), a telephone list frame (58.5%) and a random digit dialling frame (1%). Multiple cycles can be combined. Data used for these analyses

were collected from 2011 January 01 to 2012 December 31. The combined (household and person) response rate for 2011–2012 was 68.4%. Data were collected using both CAPI and CATI. Statistics Canada calculated sample weights. We obtained data from Statistics Canada; only microdata from respondents agreeing to share their data with the Public Health Agency of Canada and Health Canada were included.

Measures

Variables common to both surveys

Positive mental health

The MHC-SF consists of 14 items reflecting emotional, psychological and social well-being. All items are asked using the following format: "During the past month, how often did you feel...?" Response choices include "never," "once or twice," "about once a week," "about two or three times a week," "almost every day," and "every day." In the CCHS, Item 6 is worded according to the original MHC-SF questionnaire: "society is becoming a better place for people like me." Since its addition to the CCHS, however, Keyes has suggested changing this item to "society is becoming a better place for all people" or "our society is a good place," but this change has not been implemented on the CCHS surveys.[9]

The original scoring method ascribed the values of 1 through 6 to response categories "never," "once or twice," "about once a week," "about two or three times a week," "almost every day," and "every day." However, we created an alternative scoring method that more accurately reflects the underlying metric of the response categories, converting the semantic content of the response category into days and a ratio scale. "Every day" was ascribed a value of 28 days (4 weeks × 7 days per week); "almost every day" 20 days (4 weeks × 5 days per week); "about two or three times a week" 10 days (4 weeks × 2.5 days per week); "about once a week" 4 days (4 weeks × 1 day per week); "once or twice" 1.5 days; and "never" 0 days. We used both scoring methods for the CFA in separate models.

Demographic variables

Sex, age group, best estimate of household income, marital status and employment status were all self-reported, except in the case of nonresponse on income, in which case Statistics Canada imputed missing data.

Variables on the CCHS-MH 2012

The following variables were used in analyses of criterion-related validity:

Self-rated mental health (SRMH) was measured by a single question which asks the respondents, "In general, would you say that your mental health is: excellent, very good, good, fair or poor?" This question was also dichotomized as "fair," "poor" and "good" versus "very good" and "excellent."

Life satisfaction was also measured with a single question: "Using a scale of 0 to 10, where 0 means 'very dissatisfied' and 10 means 'very satisfied,' how do you feel about your life as a whole right now?" This question is consistent with OECD recommendations on measuring life satisfaction.[24]

Sense of belonging was measured with a single question: "How would you describe your sense of belonging to your local community? Would you say it is...: very strong, somewhat strong, somewhat weak, very weak?"

Social support was measured through the Social Provisions Scale by Cutrona and Russell.[25] Ten questions were used to measure five types of social provision: attachment, guidance, social integration, reliable alliance and reassurance of worth. We used a continuous scale score ranging from 0 to 40.

The Kessler Psychological Distress Scale (K6) was developed in order to discriminate cases of serious mental illness from no-cases based on nonspecific psychological distress symptoms in the US National Health Interview Survey. We used the six-item version (K6) for these analyses, with a continuous scale score ranging from 0 to 24.[26]

The CCHS-MH 2012 implemented the World Health Organization Disability Assessment Schedule 2.0 short version (12 items).[27] Scores range from 0 (no disability) to 100 (full disability).

Negative social interactions were measured using four questions assessing exposure to negative social interactions based on work by Krause.[28] We combined responses on the four questions to create a scale score ranging from 0 to 12.

Analysis

Descriptive statistics

We calculated descriptive statistics and a correlation matrix for all items in the test sample (CCHS-MH 2012). We calculated Cronbach's alpha for the entire instrument and three subscales. We conducted our analyses in SAS Enterprise Guide 5.1 (SAS Institute Inc., Cary, NC, USA). All analyses were weighted to account for the multistage sample design. Because bootstrapping was not available for CFA or correlation analyses, we used rescaled weights for all analyses.

Confirmatory factor analysis

The CCHS-MH 2012 was used to test the original model. We conducted confirmatory factor analysis (CFA) with robust maximum likelihood (RML) estimation in Mplus version 7.3 (Muthen and Muthen, Los Angeles, CA, USA). RML estimation allows for the use of weights and also accounts for nonnormality of data when calculating errors. Then, we fit the final model against the CCHS 2011–2012 sample to test whether the respecified factor structure was also confirmed in a different sample. While there are disagreements in the literature about what constitutes adequate fit, we adopted those suggested by Hu and Bentler[29]: a value of at least 0.95 for comparative fit index (CFI) and Tucker-Lewis index (TLI); a value less than 0.08 for standardized root mean square residual (SRMR); and a value less than 0.06 for root mean square error of approximation (RMSEA). Because Mplus does not currently have a method to incorporate bootstrap weights into CFA, we used rescaled weights divided by the average design effect for all CFAs after consultation with Statistics Canada.

Criterion-related validity

We examined criterion-related validity through correlation analyses between MHC-SF subscales and positively and negatively related concepts (self-rated mental health, life satisfaction, sense of belonging, social provisions, psychological distress, negative social interactions and the WHO Disability Assessment Schedule). Because we are reporting multiple correlations in validation analyses, we chose a conservative p-value of $< .001$, which is

equivalent to a Bonferroni correction for 50 analyses.

Results

Confirmatory factor analysis

The CCHS-MH 2012 sample reflected the Canadian household population living in the provinces. About half of the sample was male, and the mean age was 47.2 years. Just over three-quarters of participants responded to the survey in English, 22% responded in French and less than 1% responded in another language. Almost two-thirds of respondents reported a somewhat strong or very strong sense of belonging to their community. The mean life satisfaction score was 7.95 on a 0-to-10-point scale. Seven percent of respondents had a level of distress on the Kessler Psychological Distress Scale (K6) greater than or equal to 9, which is consistent with levels of distress seen among people experiencing a depressive episode or anxiety disorder[26] (data not shown).

The CCHS 2011–2012 reflected the Canadian household population living in the provinces and territories. Men made up about half of the survey population. The mean age of respondents was 47 years. English was the most frequent language of response (74% of respondents), while 21% responded in French and 5% responded in another language (data not shown).

MHC-SF responses

Responses to MHC-SF items on the CCHS 2012 were generally high on a scale of 1 to 6 (Table 1). Mean responses on a 6-point scale ranged from a low of 3.78 on Item 6, "our society is becoming a better place for people like you," to a high of 5.44 on Item 11, "you had warm and trusting relationships with others." Univariate normality of responses using the original scaling was poor: kurtosis was greater than 3.0 for four variables. In contrast, kurtosis and skewness were acceptable for all variables when the days scaling was used. Missing data on the CCHS 2012 sample was less than 2% for all items, except for three items on the social well-being subscale. One of these items (Item 6) approached 5% of missing data (4.8%). Ninety percent of the sample had complete data on all 14 items.

There were substantially higher levels of missing data on the MHC-SF items in the CCHS 2011–2012 sample, ranging from 5.7% to 14.0%, but item means were similar. Missing data were highest on the items for the social subscale (7.7%–14.0%). Correlations between items ranged from 0.58 to 0.62 for the emotional well-being subscale; 0.28 to 0.55 for the social well-being subscale; and 0.36 to 0.51 for the psychological well-being subscale (data not shown). Correlations in these ranges indicate good factorability of items. Cronbach's alpha approached an acceptable level for the emotional well-being subscale at 0.82, the psychological well-being subscale at 0.82 and the social well-being subscale at 0.77.

We tested the three-factor structure proposed by Keyes through CFA using robust maximum likelihood (MLR) estimation in Mplus. First, we ran the model using the original scaling (1 to 6) (Table 2, model 1a). This model had inadequate model fit. We then ran the model using the scaling

TABLE 1
Means, standard deviations and percent missing data by item, Mental Health Continuum—Short Form, CCHS-MH 2012 and CCHS 2011–2012, Canada, adults aged 18 years and older

	CCHS-MH 2012			CCHS 2011–2012		
During the past month, how often did you feel...	**Mean[a]**	**SD**	**% missing data**	**Mean**	**SD**	**% missing data**
1. happy	5.06	0.01	1.25	5.03	0.01	5.67
2. interested in life	5.40	0.01	0.86	5.44	0.01	6.62
3. satisfied with life	5.12	0.01	0.72	5.19	0.01	6.52
4. that you had something important to contribute to society	4.42	0.02	2.58	4.47	0.01	9.39
5. that you belonged to a community (like a social group, or your neighbourhood)	4.29	0.02	1.16	4.33	0.01	7.57
6. that our society is becoming a better place for people like you[b]	3.78	0.02	4.79	3.85	0.01	13.97
7. that people are basically good	4.83	0.01	1.33	4.84	0.01	7.66
8. that the way our society works makes sense to you	4.02	0.02	2.79	4.06	0.01	11.06
9. that you liked most parts of your personality	5.19	0.01	1.13	5.27	0.01	7.67
10. good at managing the responsibilities of your daily life	5.32	0.01	0.74	5.33	0.01	6.53
11. that you had warm and trusting relationships with others	5.44	0.01	0.73	5.44	0.01	6.68
12. that you had experiences that challenged you to grow and become a better person	4.90	0.01	1.69	4.95	0.01	8.93
13. confident to think or express your own ideas and opinions	5.29	0.01	0.81	5.29	0.01	6.92
14. that your life has a sense of direction or meaning to it	5.14	0.01	1.47	5.18	0.01	8.14

Abbreviations: CCHS, Canadian Community Health Survey; CCHS-MH, Canadian Community Health Survey—Mental Health; SD, standard deviation.

[a] Minimum for all variables is 1, maximum is 6.

[b] Keyes now recommends that an alternate version of this item be considered: "that our society is becoming a better place for all people."[7]

TABLE 2
Confirmatory factor analysis results of the Mental Health Continuum—Short Form, CCHS 2012 Mental Health and CCHS 2011–2012, Canada

	CCHS-MH 2012		CCHS 2011–2012	
	Model 1a (usual scaling)	Model 1b (days)	Model 2a (days)	Model 2b (days)
Chi-square (DF)	2046.971 (74)	2177.035 (74)	1183.464 (70)	1057.006 (26)
CFI	0.922	0.927	0.962	0.978
TLI	0.904	0.911	0.95	0.970
RMSEA (95% CI)	0.035 (0.033–0.036)	0.036 (0.034–0.037)	0.027 (0.025–0.028)	0.020 (0.019–0.021)
SRMR	0.045	0.043	0.029	0.022
AIC	878582.138	2090205.818	2086430.172	5979654.765
Difference in AIC (DF)			3775.646 (4)	

Abbreviations: AIC, Aikake information criterion; CCHS, Canadian Community Health Survey; CFI, comparative fit index; CI, confidence interval; DF, degrees of freedom; MH, mental health; RMSEA, root mean square error of approximation; SRMR, standardized root mean square residual; TLI, Tucker-Lewis index.

Notes: Model 1: Standard 3-factor model with a) 1–6 scaling and b) days scaling; Model 2: 3-factor model with correlated errors between 4 sets of items on social subscale.

representing number of days per month (Table 2, model 1b). While this model had better fit than the first model and RMSEA (0.036) and SRMR (0.043) were acceptable, CFI (0.927) and TLI (0.911) still indicated insufficient model fit.

Modification indices suggested that allowing the following residuals of items to covary would yield the greatest improvements to model fit: 8 with 6, 8 with 7, 7 with 6 and 6 with 5. The model including these correlated errors (Table 2, model 2a) had adequate model fit: CFI, TLI, RMSEA and SRMR were all above accepted thresholds. Aikake information criterion (AIC) decreased by 3775.646 with 4 degrees of freedom. While this three-factor model had acceptable fit, this was only possible with the addition of four covarying error terms that could not be explained in a theoretically meaningful way. This model is presented in Figure 1.

We fit this three-factor model against data from the CCHS 2011–2012, to confirm the stability of the model. In this sample, the three-factor model that included correlated error terms on the social well-being factor demonstrated adequate fit (Table 2, model 2b), suggesting that this three-factor model is stable across samples.

We computed a correlation matrix between the continuous subscale scores and related concepts as shown in Table 3. The correlation between the emotional and psychological well-being subscales was 0.62. Both subscales had positive and significant correlations with life satisfaction, self-rated mental health, sense of community belonging and the Social Provisions Scale. Life satisfaction and self-rated mental health were most strongly correlated with emotional well-being (0.57 and 0.47, respectively).

The subscales had negative and significant correlations with the concepts of psychological distress, negative social interactions and the WHO Disability Assessment Schedule, with stronger correlations between the subscales and psychological distress than for negative social interactions or the WHO Disability Assessment Schedule. All correlations were significant at a conservative $p < .001$ level.

In contrast, the social well-being scale had weaker correlations with related factors than either the emotional or the psychological well-being scales. In particular, the correlations with social provisions and negative social interactions with the social well-being scale were lower than expected, at 0.28 and −0.21, respectively. The correlation with sense of belonging, however, was moderate, as anticipated, at 0.40.

Discussion

Strengths and limitations

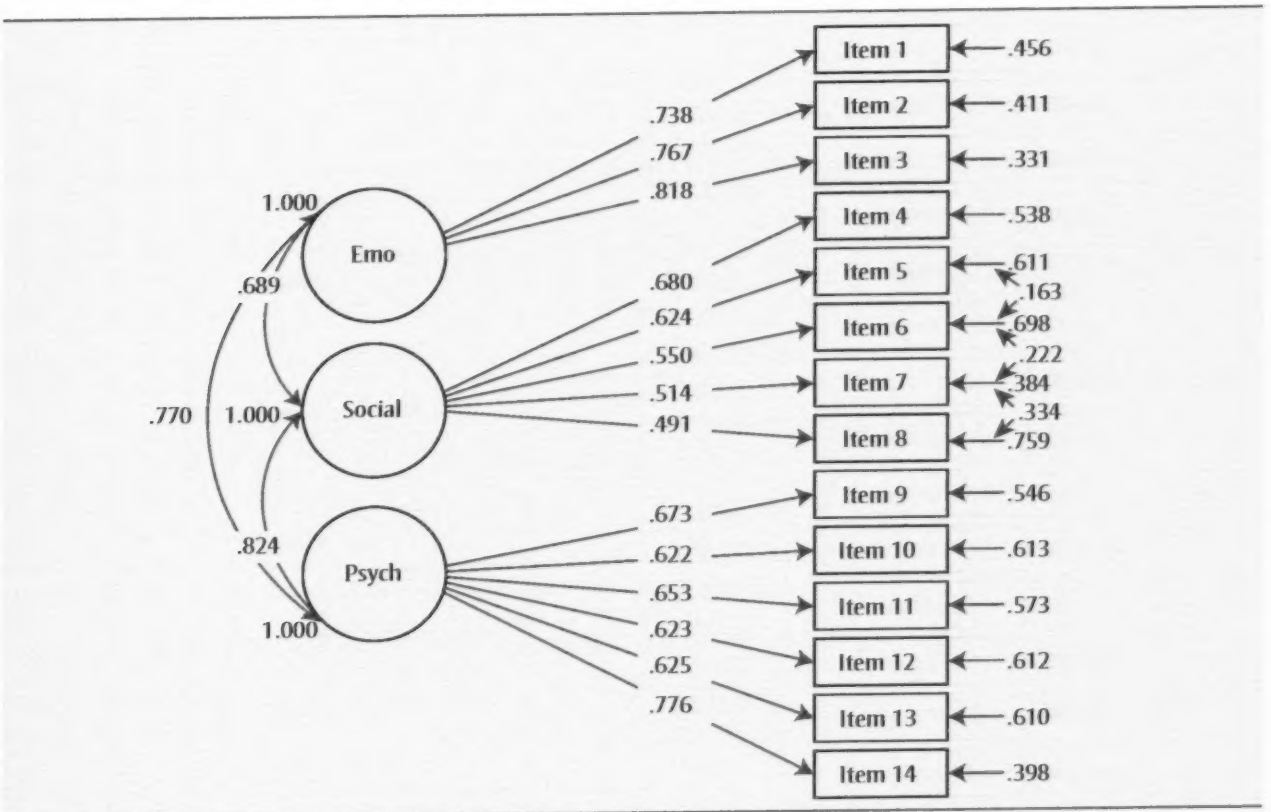
This study explored the factor structure and psychometric properties of the MHC-SF in the Canadian household population, and examined criterion-related validity of resulting scale scores. The CFA supported the theoretically based three-factor structure in the Canadian adult household population either with the original scaling (1 to 6) or when MHC-SF responses ranging from "never" to "every day" were scaled as days ranging from 0 to 28, as long as four correlated error terms were added to the model.

All of these correlated error terms were on the social well-being scale, which when combined with multiple lines of evidence (higher levels of missing data on this factor, lower correlations with related concepts), warrants caution in the use of this subscale. The poorer functioning of the social well-being scale is consistent with findings from other studies.[19] We are proposing that the emotional and psychological well-being subscales be used as measures of positive mental health in the Canadian population, noting that an alternative measure of social well-being may be needed.

We examined the criterion-related validity of the emotional, social and psychological well-being subscales by examining the correlations between these scores and a number of concepts that we theorized would be positively associated and a number that we theorized would be negatively associated. We observed significant positive correlations with both subscales for life satisfaction, self-rated mental health, sense of community belonging and social provisions. We observed significant negative correlations for psychological distress, negative social interactions and the WHO Disability Assessment Schedule.

Generally, concepts that were more closely related to emotional or psychological well-being (such as life satisfaction to emotional well-being) had stronger correlations than

FIGURE 1
Confirmatory factor analysis of the Mental Health Continuum—Short Form, standardized coefficients



Abbreviations: Emo, emotional well-being; MHC-SF, Mental Health Continuum—Short Form; Psych, psychological well-being; Social, social well-being.

Note: Items refer to questions 1 through 14 on the MHC-SF.

TABLE 3
Correlations of MHC-SF emotional, psychological and social well-being scales and related concepts, CCHS-MH 2012

	Emotional well-being	Psychological well-being	Social well-being
Emotional well-being	1.00	0.62	0.49
Psychological well-being	0.62	1.00	0.61
Social well-being	0.49	0.61	1.00
Life satisfaction	0.57	0.42	0.34
Self-rated mental health	0.47	0.41	0.29
Sense of belonging	0.24	0.27	0.40
Social Provisions Scale	0.37	0.37	0.28
Negative social interactions	−0.27	−0.26	−0.21
Psychological distress	−0.55	−0.47	−0.36
WHODAS	−0.33	−0.29	−0.21

Abbreviations: CCHS-MH, Canadian Community Health Survey—Mental Health; MHC-SF, Mental Health Continuum—Short Form; WHODAS, World Health Organization Disability Assessment Schedule.

Note: All correlations are significant at $p < .001$.

concepts that were less closely related to these concepts (such as WHO Disability Assessment Schedule to psychological well-being). These findings support the criterion-validity of the measures.

Other measures for convergent validity would have been ideal, such as self-esteem and self-actualization for psychological well-being; however, we were constrained by the existing content on the surveys used for these analyses. Future research could also examine the factor structure of measures of both mental health and mental illness simultaneously, similar to the approach taken by Lamers et al.[15]

Limitations of factor analysis should also be acknowledged. Decisions based on modification indices can result in a model that is overfit—that is, includes terms that do not have substantive meaning or that represent sample-specific characteristics that do not cross-validate. Because additional terms should be included only when they can be theoretically explained, while we chose to include the covarying error terms that modification indices suggested, it is difficult to justify these from a theoretical perspective.

There was a decrease in the proportion of missing data between the implementation of the MHC-SF on the CCHS 2011–2012 and the CCHS-MH 2012. This could indicate that the inconsistent functioning of the scale, as compared to its functioning in other studies, may be due in part to interviewer training. These analyses should be repeated the next time the MHC-SF is implemented on a large-scale Canadian survey.

Conclusion

The findings of our study suggest that while as a whole, the construct validity of the MHC-SF is supported in two large, Canadian samples, caution is warranted when employing the social well-being subscale in Canadian population surveys. Further research is required to determine why this subscale did not function as well as in other samples, what might be the cause of this differential functioning and what alternative measures may need to be developed. Given this finding, we recommend the use of an alternative measure (such as sense of belonging to community) to report on the social well-being in the Canadian adult population until a more comprehensive measure is identified and tested. Further research should examine whether the approach presented here is similarly valid in other populations and study settings.

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Conflicts of interest

The authors have no conflicts of interest to disclose.

Authors' contributions

HO, JV, JD and GJ contributed to the study design. HO analysed the data. HO, JV, JD and GJ interpreted the data. HO drafted the paper. HO, JV, JD and GJ reviewed and revised the paper. All authors read and gave final approval of this version to be published and agreed to be guarantors of the work.

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POSITIVE MENTAL HEALTH SURVEILLANCE INDICATOR FRAMEWORK
QUICK STATS, YOUTH (12 TO 17 YEARS OF AGE), CANADA, 2017 EDITION

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Positive mental health is a state of well-being that allows people to feel, think and act in ways that enhance the ability to enjoy life and deal with challenges.[1] The Positive Mental Health Surveillance Indicator Framework ("the Framework") provides comprehensive, high quality information on the outcomes and risk and protective factors associated with positive mental health across four domains (individual, family, community and society), to support research and policy development. The release of the Framework for youth aged 12 to 17 years is the second in a series; the Framework for adults aged 18 years and older was released in early 2016.[2] The Framework was developed in consultation with stakeholders working in mental health surveillance, programs and policy. The details of the development of the Frameworks across the life course, for adults, youth and children, can be found in the paper "Monitoring positive mental health and its determinants."[3] More data on positive mental health can be found online using the Public Health Agency of Canada's interactive data tool, "Infobase."[4]

INDICATOR GROUP	INDICATOR MEASURE(S)	LATEST ESTIMATE	DATA SOURCE (YEAR)
POSITIVE MENTAL HEALTH OUTCOMES			
Self-rated mental health	% of population who self-rate their mental health as "excellent" or "very good"	75.4%	CCHS (2014)
Happiness	% of population who report being usually "happy and interested in life"	77.7%	CCHS (2014)
Life satisfaction	% of population who report they are "very satisfied" with their life in general	47.7%	CCHS (2014)
	Mean life satisfaction rating (0–10 scale) among Grade 6–10 students	7.34	HBSC (2013–2014)
Psychological well-being	% of Grade 6–12 students who have high autonomy	74.7%	CSTADS (2014–2015)
	% of Grade 6–12 students who have high competence	81.5%	CSTADS (2014–2015)
Social well-being	% of Grade 6–12 students who have high relatedness	83.1%	CSTADS (2014–2015)
INDIVIDUAL DETERMINANTS			
Resilience	In development		
Coping	% of population aged 15–17 years who report a high level of coping	43.3%	CCHS-MH (2012)
Nurturing childhood environment	% of Grade 6–10 students who report having dinner together with their family five or more times per week	69.8%	HBSC (2013–2014)
	% of Grade 6–10 students who report their family is willing to help them make decisions	74.2%	HBSC (2013–2014)
Control and self efficacy	% of population aged 15–17 years who report a high level of perceived control over life chances	45.0%	GSS Social Networks (2008)
Violence	% of Grade 6–10 students who report they were in a physical fight at least once in the past 12 months	28.3%	HBSC (2013–2014)
	% of Grade 6–12 students who report they have been bullied by other students in the past 30 days	25.1%	CSTADS (2014–2015)
	% of Grade 6–12 students who report they have bullied other students in the past 30 days	14.0%	CSTADS (2014–2015)
Health status	% of population who self rate their health as "excellent" or "very good"	70.0%	CCHS (2014)
	% of population with no disability or mild disability	70.1%	CCHS (2014)
Physical activity	% of population who meet physical activity recommendations by accumulating at least 60 minutes of moderate-to-vigorous physical activity per day	4.3%	CHMS (2009–2013)
Substance use	% of Grade 9 and 10 boys who report they have had 5 or more drinks and girls who report they have had 4 or more drinks on one occasion, once a month or more in the past year	17.7%	HBSC (2013–2014)
	% of Grade 6–10 students who report they drink alcohol every week or more	6.5%	HBSC (2013–2014)
	% of Grade 7–12 students who report they have used marijuana or cannabis in the past 12 months	16.5%	CSTADS (2013–2014)
Spirituality	% of population aged 15–17 years reporting that religious or spiritual beliefs are "very important" or "somewhat important" in their daily life	45.7%	CCHS-MH (2012)
FAMILY DETERMINANTS			
Family relationships	% of Grade 6–10 students who report it is "very easy" or "easy" to talk to their parents about things that really bother them	83.2%	HBSC (2013–2014)
	% of Grade 6–10 students who have high communication in their family	58.3%	HBSC (2013–2014)
Parenting style	% of Grade 6–10 students who report that their parents trust them	77.3%	HBSC (2013–2014)
	% of Grade 6–10 students who report that their parents expect too much from them	28.7%	HBSC (2013–2014)
Family health status and substance use by family members	% of population aged 15–17 years with a family member who has problems with their emotions, mental health or use of alcohol or drugs	29.4%	CCHS-MH (2012)
	% of population aged 15–17 years with a family member who has problems with their emotions, mental health or use of alcohol or drugs, who report that their life is affected "a lot" or "some" by their family member's problems	26.5%	CCHS-MH (2012)
Household composition	% of population who live in a lone-parent household	18.0%	CCHS (2014)
	% of population who live in a two-parent household	69.7%	CCHS (2014)
Household income	% of population under the age of 18 years living below low-income cut-offs, after tax	8.5%	CIS (2014)

INDICATOR GROUP	INDICATOR MEASURE(S)	LATEST ESTIMATE	DATA SOURCE (YEAR)
COMMUNITY DETERMINANTS			
Community involvement	% of Grade 6–10 students who are involved in at least one club or organization	88.9%	HBSC (2013–2014)
Social networks	% of Grade 6–10 students who report they can count on their friends when things go wrong	74.3%	HBSC (2013–2014)
	% of Grade 6–10 students who have friends to share their joys and sorrows with	79.2%	HBSC (2013–2014)
Social support	% of population aged 15–17 years with a high level of perceived social support	95.4%	CCHS–MH (2012)
School environment	% of Grade 6–10 students who report they feel they belong at their school	63.2%	HBSC (2013–2014)
Neighbourhood social environment	% of Grade 6–10 students who report they can trust people in the area where they live	60.2%	HBSC (2013–2014)
	% of population aged 15–17 years who report that their neighbourhood is a place where neighbours help each other	90.4%	GSS Victimization (2014)
	% of population aged 15–17 years who report that social disorder in their neighbourhood is "a very big problem" or "a fairly big problem"	6.3%	GSS Victimization (2014)
Neighbourhood built environment	% of Grade 6–10 students who report there are places such as recreation centres, parks and shopping centres to spend free time in the area where they live	74.2%	HBSC (2013–2014)
SOCIETAL/STRUCTURAL DETERMINANTS			
Inequality	In development		
Discrimination and stigma	% of population who experienced unfair treatment at least once in the past year based on characteristics such as gender, race, age or appearance	39.1%	CCHS (2013) Discrimination Rapid Response

Abbreviations: CCHS, Canadian Community Health Survey; CCHS-MH, Canadian Community Health Survey—Mental Health; CHMS, Canadian Health Measures Survey; CIS, Canadian Income Survey; CSTADS, Canadian Student Tobacco, Alcohol and Drugs Survey; GSS, General Social Survey; HBSC, Health Behaviours in School-Aged Children.

Note: "In development" refers to measures that are under development either because a data source is currently not available or because more research has to be done to identify a promising measure and data source.

Suggested citation: Centre for Chronic Disease Prevention. Positive Mental Health Surveillance Indicator Framework: Quick Stats, youth (12 to 17 years of age), Canada, 2017 Edition. Health Promot Chronic Dis Prev Can. 2017;37(4):131-2.

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Cox JL, **Dai S**, Gong Y, et al. The development and feasibility assessment of Canadian quality indicators for atrial fibrillation. Can J Cardiol. 2016;32(12):1566-9. doi: 10.1016/j.cjca.2016.02.059.

Hennessy DA, Tanuseputro P, Tuna M, Bennett C, Perez R, **Shields M**, et al. Population health impact of statin treatment in Canada. Health Rep. 2016;27(1):20-8.

Nour S, Labonté R, **Bancej C**. Impact of the 2008 global financial crisis on the health of Canadians: repeated cross-sectional analysis of the Canadian Community Health Survey, 2007-2013. J Epidemiol Community Health. 2016. doi:10.1136/jech-2016-207661.